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# **Wheat interchanges in Europe: Transport Optimization reduces emissions.**

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## **Abstract:**

Numerous Life Cycle Analysis of bread pointed out that wheat production and transportation have important impacts on the environment. But wheat is grown all around the world and it is not always consumed where it is produced. In this paper an analysis of the wheat movements around Europe is done, taking special attention on the Spanish situation. An optimization of wheat exchanges is done eliminating the import-export overlapping. This optimization entails a reduction of the number of trips by 34% and the CO<sub>2</sub> emissions reduction due to transportation is calculated to be 121.175 tons. Consequently less trips, fewer trucks, less traffic and lower emissions that brings economic, social and environmental benefits.

**Key words:** Wheat, Trades, optimization, Emissions, Environment.

## **1. Introduction:**

Bread is done mainly of cereal flours, water, yeast and salts, being wheat flour the basic ingredient. The relevance of wheat is not just because of bread, it is also the basic ingredient for many Mediterranean dishes, such as pasta or pizza. Additionally, wheat is the most important crop in the region of Europe and Central Asia [1], becoming the objective of many research studies. These studies analyzed the equivalent CO<sub>2</sub> tones emissions of growing wheat on specific countries (UK, Germany, Spain, France, Canada, US, Iran, Australia) [2-4]. They found out non negligible differences due to different aspects, such as the use of fertilizers with a 25% impact variation and the effect of rain-fed wheat or irrigation, which could double the environmental impact of wheat growing. Other works expose, along with their analysis, the environmental impact of foreigner's wheat imports, taking into account not just the agricultural processes but also the transportation [2]. With this, it could be seen that the means of transportation and distance are responsible of 10% of the Kg of CO<sub>2</sub> e. emitted to the environment. Indeed, in [3], the last step of the LCA ended with harvested wheat delivered into a naval port of Australia, which is one of the biggest wheat exporters in the world [5]. This last study revealed that only land transportation to port had a weight of about 12% of the emissions. However, the stored wheat had still an oversea trip plus some other hundreds of kilometers inland to its final destination.

Comparisons between organic or conventional wheat cultivation and harvesting have been executed, showing that, although organic wheat growth has a 10% lower environmental impact, the benefits derived from the fewer use of pesticides and the shorter transportation distances were almost counteracted by a bigger land use and farming process [6], [7]. Again, transportation was a key factor on final results, moreover considering that organic farming should be attached to short traveled distances concepts, such as the 0 Km food. It has no environmental sense to produce organic wheat and ship it some thousands of miles away. Other comparisons studied the differences between white and whole bread [4]. Wheat, as part of our food chain, has been widely studied.

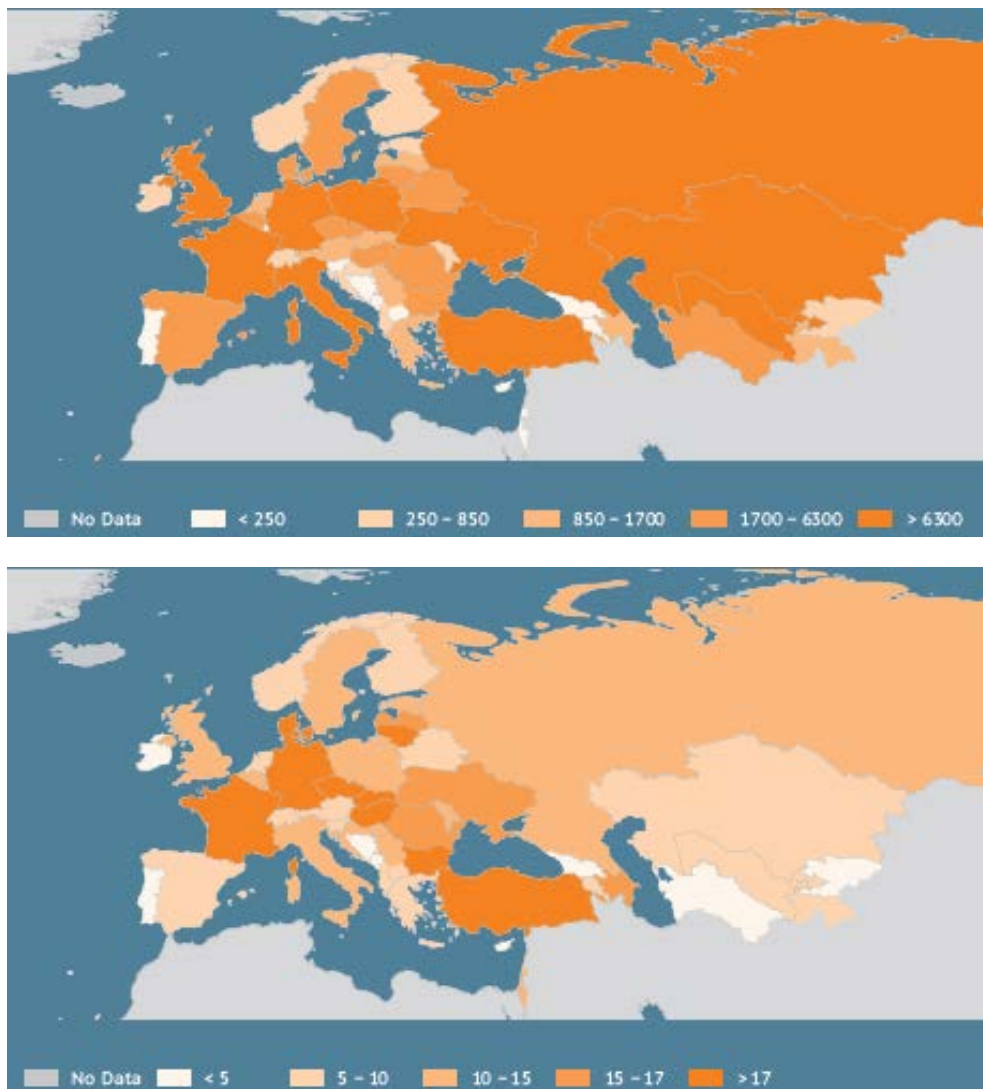
Each country around the world and within Europe has its own cultural characteristics. In a recent study under revision, we executed the LCA of an industrial bread production process from a factory located in Catalonia, Spain, which is becoming a major trend in industrialized countries: The frozen bread. In Spain, small bakeries offering different types of recently baked bread are spread all around the neighborhoods. The number of pre-cooked and frozen bread bakeries is increasing, as it was reported by the increasing frozen bread production from the aforementioned factory. Apart from the baking facilities offered to shop dealers, as there is no need to prepare the dough and estimate the day consumption in advance, this just-in-time production provides a gain on unconsumed and lost bread and therefore wheat [8]. This mass production plants concentrates the wheat demands, thus, reduces the dispersion of distribution and the kilometers of transported wheat. This evolution provides the frame for a wheat transport analysis.

As it has been demonstrated that wheat transportation has between a 10 and a 20% weight on the environmental impact of bread production, the objective of this work is to observe the wheat interchanges

between European countries and to present an optimized solution. This will help to analyze the opportunities to reduce the CO<sub>2</sub> emissions within the continent.

## 2. Material and Methods:

European countries have been trading for ages between themselves. The commerce with grain is no exception. The productivity rates depend mostly of the year climatology. For example, the inundations occurred during the spring 2013 in Germany, Check Republic, Austria and Hungary saturated the fields. On the contrary, there was less rain in UK, north of France and Benelux while in Spain, south of France and Italy it has been the most humid spring in history, giving high production rates in these regions [9]. However, the major tendencies are maintained, being France, with a 27% share of wheat production and Germany with an 18% the biggest contributors of wheat production in Europe. The total wheat production achieved the 123.75Mt in 2012 [10]. In Fig. 1, the productivity of each European country and the wheat specialization is appreciable, being France, Germany, Denmark, Check republic, Slovakia, Hungary, Bulgaria and Turkey the countries more specialized in wheat, with more than the 17% of land growing this cereal [1].



*Fig. 1: Top) Distribution of wheat production (in thousand tones) b) Wheat share of total agricultural area during 2012 [1].*

When these productivity differences are related to local demands of grain it is possible to understand the need for interchanges among countries. The commercial interactions that took place in 2012 are represented in Fig. 2, where the arrows, marking the origin, destination and volume of the interchanges go back and forth all around Europe. The data source of all these grain trades are extracted from the annual Grain Report from the journal *Stratégie Grains* [10]. These interchanges might slightly change from one year to another because of different factors, such as economics and the productivity aforementioned.

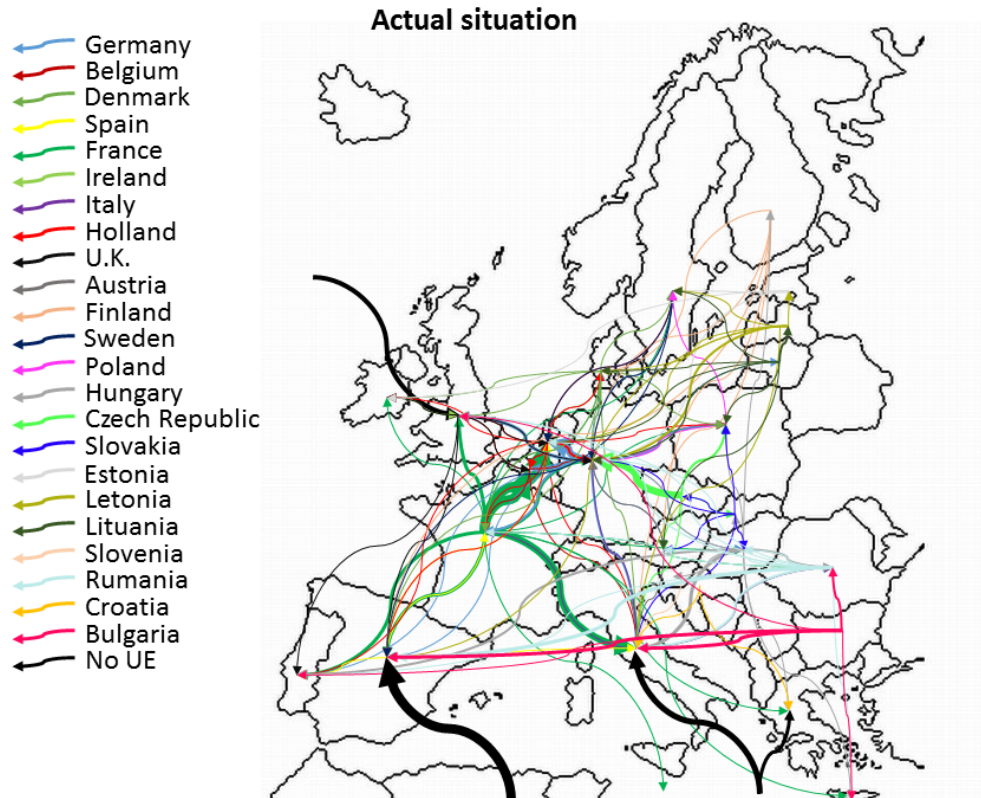


Fig. 2: Wheat interchanges amongst countries. The wider the arrow, bigger the amount [10].

In Fig. 2, non EU imports are just plotted for Spain, Italy, U.K. and Greece. These four countries consume the 85% of the Non EU imported wheat from outside Europe. Although the interchanges below 10kt are not plotted in Fig. 2, it is difficult to follow all the visible arrows because of the huge quantity of exchanges. it is also interesting to see that, most of the imported grain in Spain comes from the most distant countries in Europe (Rumania, Bulgaria, Estonia, Sweden and overseas (UK)... ) or from outside Europe (USA, Canada, and Australia are the worldwide exporters...) while the biggest producer and exporter in Europe is its neighbor, France. But then again, it all seems to go in an incomprehensible way: While France focuses the exports to the right side of the map, the countries touching Russia must fill the blanks left on the countries touching the Atlantic ocean (Spain is the most important importer of Rumanian and Bulgarian wheat).. Additionally, it is also visible that there are some countries which are mainly receivers, such as Spain which imports around 2.000kt of wheat and exports just 61kt, similar situations are reported on Italy, Greece, Ireland... On the other hand, there are countries specialized on exportation, such as Bulgaria (more than 1.600kt exported and just 10 imported), Hungary or France (the biggest dealer, with more than 7.000kt sold and just 346kt imported). And finally, there are those doing exports and imports in a balanced way. These are the astonishing cases of Germany (importing almost 2.700kt and exporting around 4.000kt) or Denmark (importing 459kt and exporting 681kt) [10].

To facilitate the global picture, in Fig. 3, the countries are identified as net importers or exporters by colors. This helps to determine the countries with actual needs of wheat and the ones having excess. Moreover, it helps to observe that there is no special need to proceed with the transportation knot from figure2.

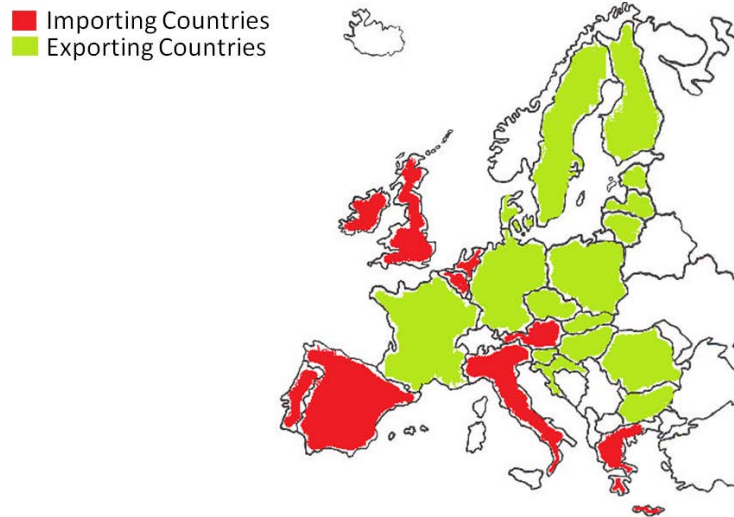


Fig. 3: Countries visualization as net importers or exporters (from column 3 table1).

Transportation has an important impact on Global Warming, being responsible of more than a 17% of the Greenhouse Gas emissions [11], therefore, the first opportunity to reduce these emissions might come from the “balanced” trade among countries. That means, in the case of the previously mentioned Germany, if it does not export the 4.000kt there would be no need to import 2.700kt of wheat. So, there would be 5.400kt (two times 2.700kt) of transported wheat reduction. Consequently, imports could be saved by not exporting wheat as it is shown in Table 1.

	Exports (kt)	Imports (kt)	needed transfers (kt)	Possible savings (kt)
Germany	3.972	2.687	1.285	2.687
B/L	330	2.806	-2.476	330
Denmark	681	459	222	459
Spain	60	2.116	-2.056	60
France	7.162	346	6.816	346
Greece	0	476	-476	0
Ireland	21	442	-421	21
Italy	46	3.345	-3.299	46
Holland	418	3.501	-3.083	418
Portugal	21	834	-813	21
U.K.	580	1.970	-1.390	580
Austria	365	386	-21	365
Finland	145	56	89	56
Sweden	333	136	197	136
Poland	787	173	614	173
Hungary	1.236	64	1.172	64
Czech Rep.	711	50	661	50
Slovakia	182	86	96	86
Estonia	198	38	160	38
Letonia	626	208	418	208
Lituania	547	87	460	87
Slovenia	66	64	2	64
Xipre	0	104	-104	0
Malt	0	25	-25	0
Rumania	749	609	140	609
Bulgary	1.653	20	1.633	20
Croatia	199	0	199	0
UE	21.088	21.088	13.743	6.924

Table 1: kilo tones of wheat exported and imported per country in EU in 2012 [10]. Considered needs from export-import subtraction and derived transfer saved kt of wheat.

In order to proceed with the optimization, it was assumed that all grains had the same quality even though some derivate products might use specific wheat due to its color or special properties. The optimization done is based on eliminating the import-export superposition, as it is visible in Table 1. In fact, Germany and France exchange the same amount of wheat (around 300kt, almost the 85% of French imports). This same import-export superposition happens with Denmark and Germany and, in a less noticeable way, in most of the countries. As it is visible in table1 these evitable transportations are around a third of the total amount of exchanges. From a non-economical sight, it has not much sense except for the border regions, where it might be more profitable to exchange wheat with the neighbor country than to cross the whole country to supply the needs of a region. The optimization was done by filling the country needs using the shorter distance from right to left, i.e, from Portugal to Spain, from Spain o France and so on. Additionally, in order to simplify the calculations all the productions, all trips among countries are considered to be from the geographical center of the country to the center of the other country. I.e., all the exchanges from Spain to France have 1029 km, the distance travelled for all the exchanges between France and Greece have 2344 km and so on.

For the calculations, it was assumed that the trips were done by trucks capable to transport 25 tons of cargo. The number of trips was obtained dividing the total amount of grain to be transported by the truck capacity load. The global warming potential (GWP) per trip was calculated multiplying the CO<sub>2</sub> equivalent emissions of these trucks, considered to be 0.49 kg CO<sub>2</sub> e./km [13] by the number of kilometers travelled.

In the end wheat is treated to produce bread, pasta, pizza or many other food derivative products, including animal feeding. Then again, this transformed wheat is shipped abroad and may come back to the original country as manufactured food together with the environmental impact it brings within. As an example, Fig. 4 presents the exports of the pasta *Gallo* brand products around the world. The main manufacturing plant is located in Spain, which is a net wheat importer country. More examples are the Barilla pasta brand, in its website it can be read that the Group operates directly in 20 countries, exports its products to over 100 countries and owns 43 manufacturing plants (13 in Italy and 30 abroad); or the Spanish multinational Europastry group, which exports to 20 countries having subsidiaries in Portugal and France. It is not the issue of this work to enter into this detail, but it gives an image of the enormous amount of trips wheat can do before being finally consumed.



Fig. 4: “Pastas Gallo” exports from Spain to the world.[12]

### 3. Results & Discussions:

Using the described methodology, the GWP of the actual transportation situation is stated to be 449.027 t of CO<sub>2</sub> e. caused by more than 843.500 trucks traveling an average distance of 1.088 km per trip. After the transfer reduction presented in table 1, an optimization of the wheat interchanges has been done maintaining the net import-export balances within Europe. The international balances are not taken into account even though some countries receive an important amount of the imported grain from the outside (42% in the case



of Spain, which is the principal wheat importer from outside Europe). Fig. 5 shows the results of this optimization. It can be noticed that there are no crossing arrows, the receivers and donors are easily identified and the exporting countries coincide with the ones presented in Fig. 3. In general, the movement of wheat is from east to west, except from the interchange between France and Belgium.

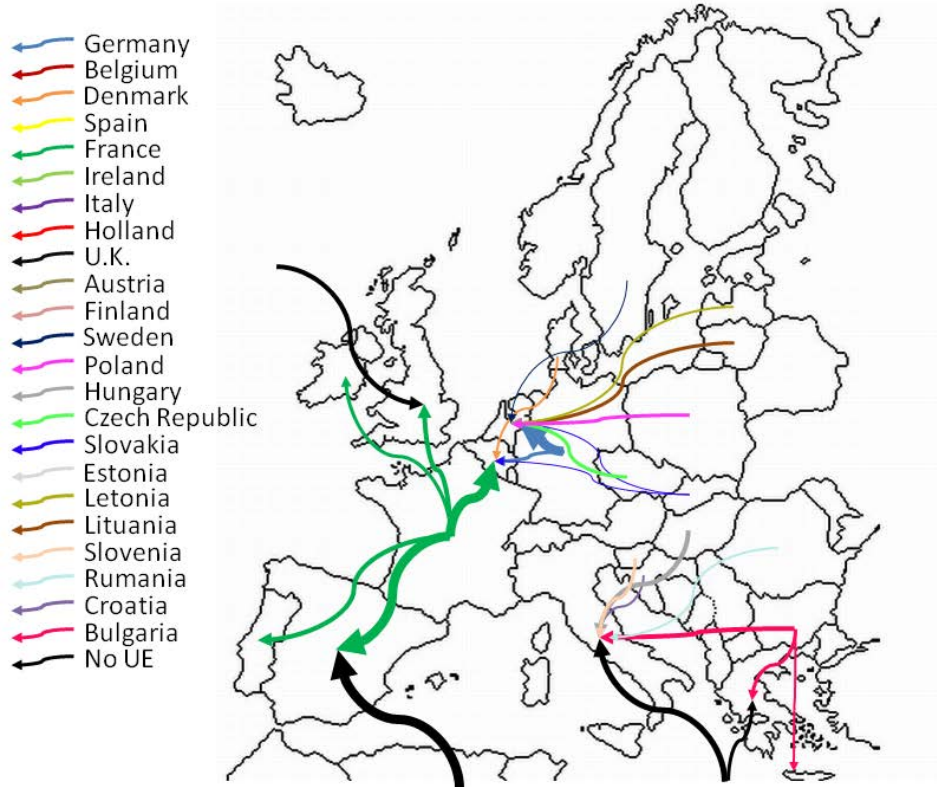


Fig. 5: Wheat interchanges amongst European countries after the transport optimization.

With these results, the transaction lump is untied and simplified, the travelled kilometers are reduced significantly and the CO<sub>2</sub> emissions too. The final amount of trucks moving around Europe would be about 566.480, which implies 276.960 trucks less than the initial condition. Consequently, the CO<sub>2</sub> tones emitted correspond to 327.851 tCO<sub>2</sub> e. [13] resulting from an average distance of 1.181 km per trip km. The calculations are presented in Table 2. The GWP savings are reduced by 121.176 t of CO<sub>2</sub> e.

Case	kt wheat	Truck tones	Truck trips	Average km	kg CO <sub>2</sub> /km	kg CO <sub>2</sub> e.
Base	21.088	25	843.520	1.088	0,49	449.026.690
Optimized	13.884	25	566.480	1.181	0,49	327.851.278

Table 2: Kt of wheat trades, n° of trips and GWP generated in the base case and using the optimized proposal (in kg CO<sub>2</sub> e.).

A fine observer would have noticed that the number of kilometers per trip in the actual situation is lower than the one in the optimized proposal. In fact, nowadays there are more interchanges between nearby countries and just a few of them from widely separated countries (Fig. 2). However, the environmental impact improvement is obtained because the total amount of trips is reduced by a 34% while the distance increase is just an 8%.

A reduction of the amount of wheat transfers entails economic reductions. Assuming that full loaded transportation by truck costs is around 1€/per kilometer [14], [15], 247.297.000€ are willing to be earned. Now that we are into economics, it seems correct to consider the CO<sub>2</sub> carbon trade market, where carbon is sold at an average of 4€/tone of CO<sub>2</sub> e. [16]. The offer rises up to 485.000€, which might be really interesting for developed countries.

### 3.1 Wheat final use:

Since now, the analysis has not entered into the inner reasons of wheat demands and consumptions of each country. Arrived to this point where and optimization of the transportations has been done for the actual demands, it has been thought that the next step of the analysis should take a deeper look to the real causes of these demands.

In 2012, a 49% of the wheat consumption in Europe was used for human / industrial purposes, 42% was used for animal feeding, a 3% was used as biofuel and a 6% was used as seeds and for other purposes. However, this repartition is not equal for all countries. For example, only 8 countries used wheat as biofuel (France 950t, Belgium 797t, Sweden 445t, U.K. 399t, Germany 337t, Austria 269t, Bulgaria 114t and Letonia 57t). Although France is the country spending more tones of wheat for this purpose, its use corresponds to a 5%, while for Belgium it supposes 18% and for Sweden it rises up to 23%, which is the highest rate in Europe.

A similar widespread distribution occurs for human and animal wheat distribution. Germany is the country destining more tones of wheat for animal consumption (9389t) followed by France (7238t), U.K. (6492t), Spain (4515t), Denmark (3290t) and the rest of countries. Germany uses 47% of its wheat for this purpose, which is a little higher than the European average. However, it is Denmark the country that surprises the most, destining almost 85% of its wheat resources to feed animals. A total of 7 European countries use wheat to feed animals more than for human food preparation: Ireland (62%), Finland (62%), Slovakia (57%), Lithuania (54%), Holland (53%) and Spain (50%). On the other hand, just 2 regions use no wheat for animal feeding (Malta and Cyprus), followed by Portugal with only a 5%.

In summary, not all the grain accumulated on a country is used for human needs, and even more, not even for country essential needs, as it has been reported that there are countries exporting more wheat than they consume. An optimization on logistic distribution of wheat reports fast and visible improvements. However, if real improvements are desired, efforts should not just focus on raw material transactions, it is necessary to think about local redistribution of production according to local needs.

#### **4. Conclusions:**

Wheat production in Europe is not balanced, therefore trades are needed. Nowadays, there are more than 843.500 shipments done to exchange the wheat among European countries that suppose a total amount of 449.027 t of CO<sub>2</sub> e. emitted by trucks. However, about a third part of these trades could be eliminated easily by not exporting country's wheat if imports are needed afterwards. An optimization of the wheat exchanges has been presented in this paper resulting in 277.000 fewer trips that suppose a 34% reduction. The optimization reported a reduction in the total mileage by 247.297.000 km even though the average trip distance was increased by a 8%. Finally, the total CO<sub>2</sub> emissions were reduced by 121.175 tones and economic advantages are presented.

Additionally, it has been observed that about half of the wheat production is intended for human food products, leaving almost 42% for animal feeding, which is another unbalanced market to be analyzed in future works, and for the use in biofuels (2%).

The kind of transport optimization presented here provides a fast environmental impact reduction without any investment and should be enhanced by the European Union in addition to the transportation directives applied and the incentives of cleaner technologies to force transportation engines to be more efficient and have less pollutant trucks.

#### **5. Acknowledgments:**

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